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A BRIEF CAINOZOIC HISTORY OF THE UPPER DARLING BASIN

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ABSTRACT: The Upper Darling Basin Cainozoic stratigraphy is characterized by two major phases. The earlier, commencing in the late Cretaceous, is a phase of weathering and the formation of two silcretes, one in the early Eocene, the other in early Pliocene. During this phase only limited sedimentation occurred, from Eocene to Miocene, in the eastern parts of the Basin.

During the late Miocene thin but widespread fluvial sheet gravels were deposited. These were a precursor to the second phase which was one of widespread fluvial deposition within the Basin. It began in the late Pliocene and is still continuing. Three formations have been recognised within the fluvial sequence.

INTRODUCTION

Considerable effort has been expended in the Upper Darling Basin (Fig. 1) in delineating the pre-Cainozoic geology of the Great Artesian Basin. The Cainozoic geology has however received little attention. Senior *et al.* (1968), B. Senior (1972), D. Senior (1972, 1973), Idnurm and Senior (1978), Taylor (1976, 1978) have delineated the stratigraphy of the Cainozoic in the Queensland portion of the Basin but the greater part, which lies in New South Wales, has received only passing attention from geologists.

The stratigraphy presented in this paper is based on a small area (*c.* 400 km²) studied by the author (Taylor 1976), and on re-examination of records of the New South Wales Water Resources Commission. Previous studies of the Cainozoic are restricted to brief accounts of the weathering stratigraphy in the Lightning Ridge area (Whiting & Relph 1961, Offenberg 1968) and Taylor (1978) records the weathering chronology of outcrops on ridges to the west of Lightning Ridge. The Cainozoic stratigraphy of the basin-fill has not been considered by previous authors. Brunker (1967, 1968) and Offenberg (1968) simply record the Upper Darling basin-fill as 'Cainozoic Undifferentiated'. Martin (1969, 1973) has established a chronology based on pollen in sediments from the eastern portion of the basin between Narrabri and Wee Waa.

GEOLOGICAL SETTING

The Upper Darling Basin is the southern portion of the Darling-Warrego Basin of Brown *et al.* (1968). The Cainozoic deposits of the Basin can be considered to be a continuation under different tectonic and sedimentary control of the Mesozoic sedimentation of the Surat Basin. The Darling-Warrego Basin is bounded on the east and south by Palaeozoic rocks of the New England and Lachlan Fold Belts and in the north and west by Mesozoic sediments of the Great Artesian Basin. The Upper Darling Basin is separated in the west from the remainder of the Darling-Warrego Basin by low ridges of Cretaceous sediment. The sediments of the Upper Darling Basin unconformably overlie the Mesozoic sediments of the Surat Basin.

The stratigraphy of the Upper Darling Basin can be conveniently split into a late Cretaceous-early Tertiary period of weathering and localised sedimentation and a late Tertiary to Recent period of widespread fluvial deposition.

LATE CRETACEOUS-EARLY TERTIARY

At the close of deposition of the labile sediments of the Rolling Downs Group (Table 1, Section 4) in the Lower Cretaceous the regional slopes in the Basin were in a generally northeasterly direction (Offenberg 1968, Power & Devine 1970).

During the late Cretaceous the Rolling Downs

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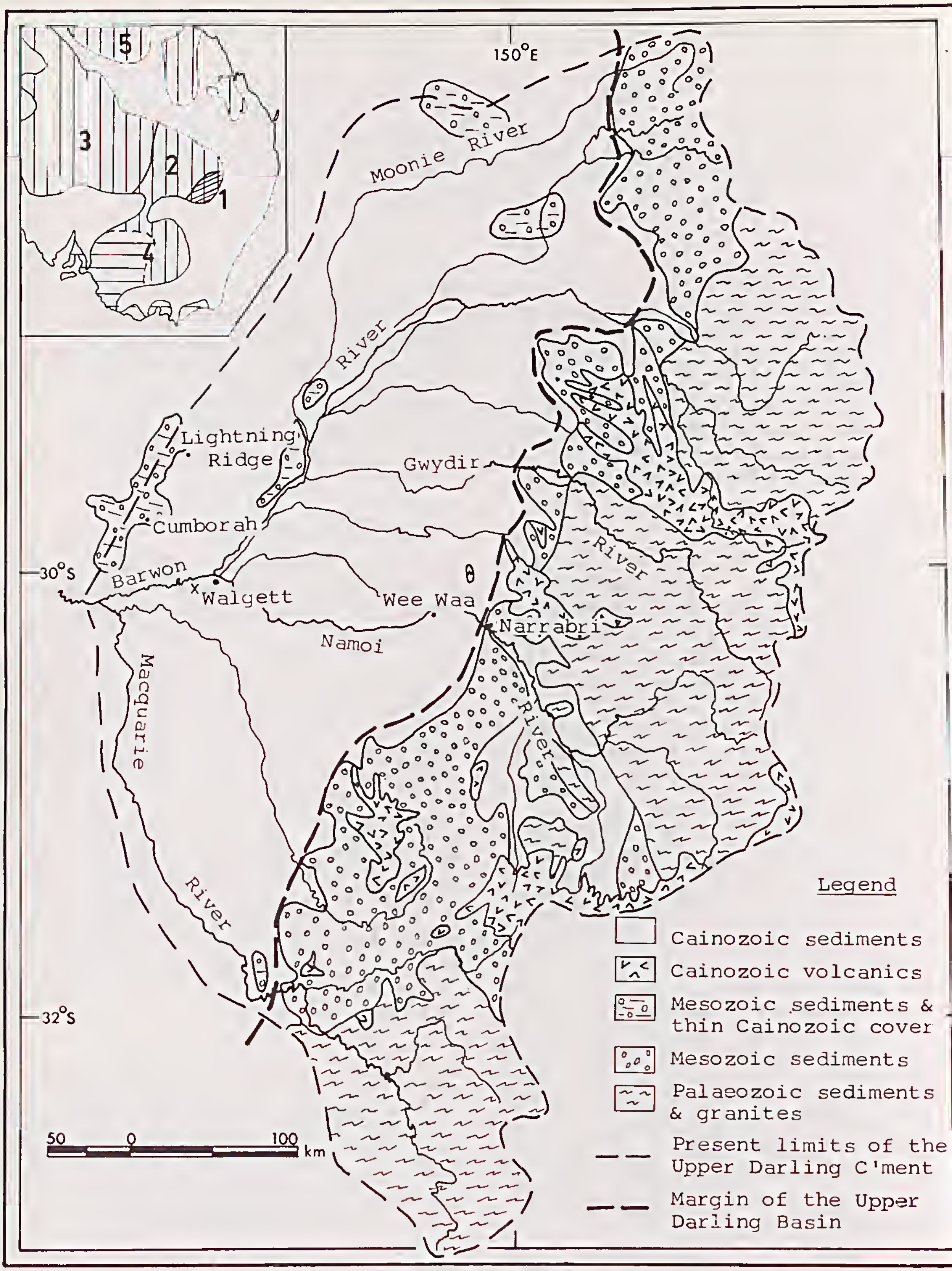

FIG. 1. — Map showing the localities mentioned in the text together with surface geology. The locality of the stratigraphic section in Fig. 3 12 km west of Walgett is marked (X). The inset shows the major Cainozoic basins of eastern Australia; marine basins are horizontal lines, terrestrial are vertical. 1. Upper Darling Basin; 2. Darling Warrego Basin (Brown *et al.* 1968); 3. Eyre Basin; 4. Murray Basin; 5. Karumba Basin.

Group was exposed to weathering and erosion by uplifts along the eastern margin of the Basin (Wellman 1971). Senior *et al.* (1968), B. Senior (1972), D. Senior (1972, 1973), Idnurm and Senior (1978) and Taylor (1976, 1978) all discuss the weathering of the Rolling Downs Group. The rocks were intensely weathered to depths of up to 100 m, forming weathering profiles dominated by kaolinite and quartz with occasional ironstone concretions and bands near the surface. This weathering phase culminated with the formation of silcretes and ferruginous crusts in the early Eocene (Idnurm & Senior op. cit.). In the Cumborah-Walgett Region this silcrete is identifiable over large areas of Cretaceous outcrop and is called the Llanillo Silcrete (Taylor 1978).

The Llanillo Silcrete is a silicified horizon at or near the top of the weathering zone developed in the Rolling Downs Group. Unlike its equivalents in southeastern Queensland (Senior 1972) it is not associated with the ferruginous nodules and ironstone crusts dated by Idnurm and Senior op. cit. Taylor (1976) however considers it to be of the same age, i.e. early Eocene. Wellman (1971) showed that during the late Cretaceous-early Tertiary the eastern highlands of the New England region were uplifted some 800 m.

For the period from the formation of the Llanillo silcrete to the Miocene there is no record of deposition in the western two thirds of the Upper Darling Basin. However, in the easternmost section of the Basin, Martin (1973) records Eocene to late Miocene pollen at depths up to 107 m (Fig. 2). Deposition during the early Tertiary was restricted to the eastern portion of the Basin suggesting that, at least for some of the early Tertiary, palaeoslopes were still towards the east over the greater part of the Basin or that this early sedimentation was restricted by the change in gradient to a belt proximal to the eastern highlands. Fig. 2 shows that if the latter was the case then a downwarp of some 40 m in the Narrabri-Wee Waa region must have occurred post-Eocene.

A sheet gravel, the Cumborah Gravel (Taylor 1972) unconformably overlies the Llanillo Silcrete and the deeply weathered Cretaceous sediments on the ridges in the Lightning Ridge-Cumborah area, and is present also under the more recent fluvial sediments in the Walgett region. These gravels contain chert, quartz, jasper and silicified wood fragments which originated from the Jurassic sediments flanking the western margins of the eastern highland. They also contain clasts of weathered Rolling Downs Group sediment and fragments of the Llanillo Silcrete. The gravels attain a maximum thickness of 5 m but are generally less than 1 m.

The presence of these gravels indicates a change in the palaeoslope and hence some Basin tectonism between the Eocene and when they were deposited. This change in palaeoslope between the Eocene and the deposition of the Cumborah Gravel is the time of origin of the Darling valley as it is today. The age of the Cumborah Gravels is unknown except that they post-date the Eocene and pre-date the oldest fluvial valley fill of late Pliocene age.

The top of the Cumborah Gravel has been silicified to form the Mt. Charlotte Silcrete (Taylor 1976). This silcrete is not associated with ironstones or laterites but does represent a second and less intense phase of weathering in the Basin. Idnurm and Senior (1978) also record a second phase, which they date at late Oligocene, in southwestern Queensland. This Oligocene event is not related to that which produced the Mt. Charlotte Silcrete but Senior (pers. com.) records a third silicification event in central Queensland which in all probability does correlate with the Mt. Charlotte Silcrete.

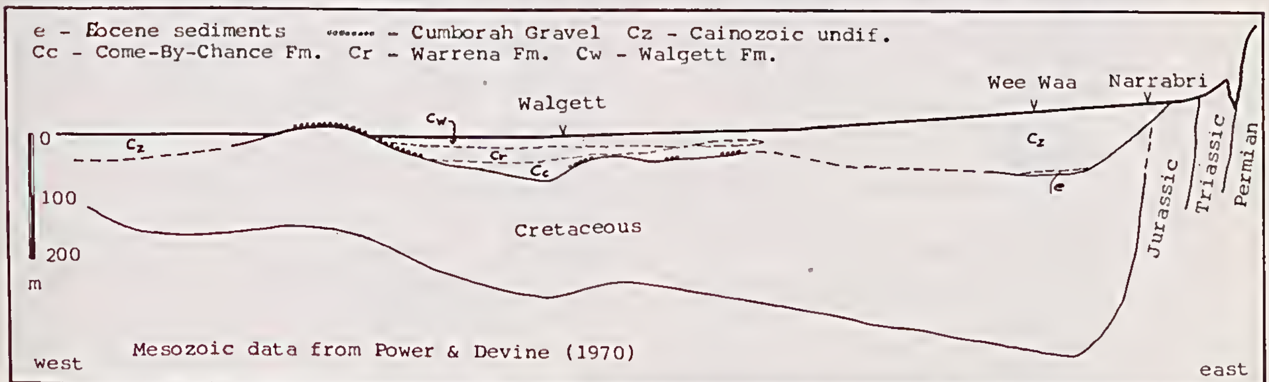

FIG. 2. — Section across the Upper Darling Basin from east to west through Walgett and Narrabri.

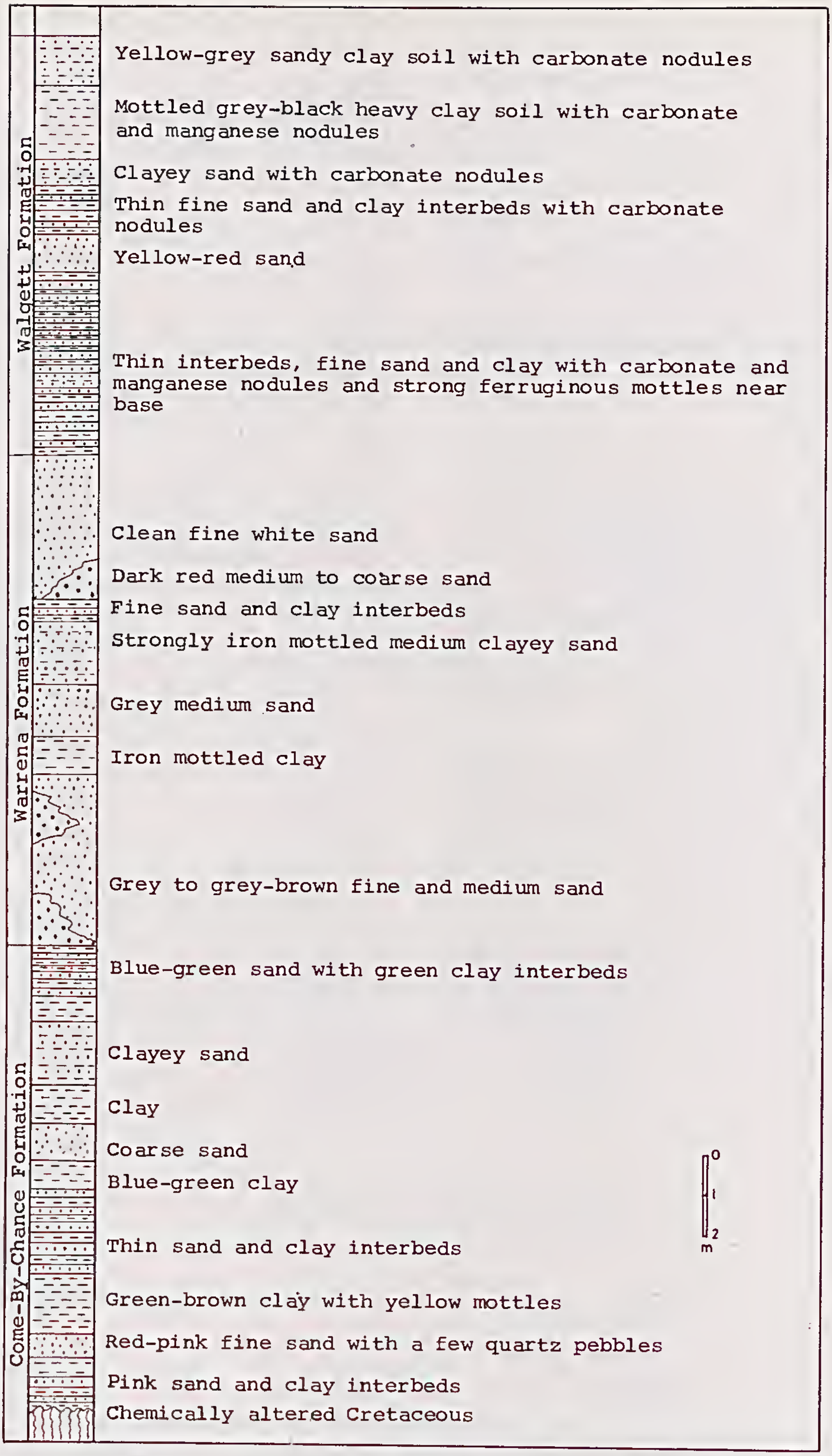

FIG. 3. — A log of the Cainozoic sequence from 12 km west of Walgett. Bore site is marked (X) on Fig. 1.

LATE TERTIARY TO RECENT

During the late Pliocene or early Pleistocene the eastern highlands were uplifted some 200 m (Wellman 1971). As with the earlier vertical tectonism in the eastern source regions this movement too was accompanied by gentle folding and some faulting in the Basin. It is this movement which folded the Cumborah Gravel and faulted it; at Mt. Charlotte the Cumborah Gravel is downfaulted against the Llanillo Silcrete and deeply weathered Rolling Downs Group.

It was during this period, Pliocene to Recent, that the 50 m or so of fluvial deposits accumulated in the greater part of the Upper Darling Basin. Offenberg (1968) and Brunker (1967, 1968) report some 120 m of 'Cainozoic undifferentiated' in the Upper Darling Basin. With the exception of the area along the eastern Basin margin where Eocene sediments occur, the greatest depth of fluvial sediments recorded by the present author is 60 m near Walgett. The thicker sequences in this area noted by previous authors are taken to result from their failure to recognise the thick weathered zone on top of the Rolling Downs Group.

Three formations have been recognised in the Basin-fill (Fig. 3). The oldest is the Come-By-Chance Formation. This unit unconformably overlies the Cumborah Gravel or the deeply weathered Rolling Downs Group. It is overlain, apparently conformably, by the Warrena Formation. The Come-By-Chance Formation is an interbedded sequence of muds and sands up to 19 m thick. The basal portions contain reworked Cumborah Gravel; the remainder consists of interbeds of fine to medium sub-feldsic sands and kaolinitic muds. A sample from 4.5 m above the formation base yielded late Pliocene pollen (Dr. J. Owen, pers. comm.).

The Come-By-Chance Formation is coarser to the northeast of Walgett and finer toward the southwest and west, suggesting that the depositing rivers flowed in similar patterns to those of today.

The Warrena Formation is about 12 m thick in the central area of the Basin and is essentially a medium sand. The sands are dominantly quartzose with up to 5% feldspar. The clay minerals from thin clay partings and beds (Fig. 3) are kaolinitic towards the base of the unit, becoming more montmorillonitic towards the top. The uppermost 1-2 m of the sequence is strongly pedogenised in some areas, suggesting the overlying Walgett Formation is disconformable.

The age of the Warrena Formation is unknown although, using approximate sedimentation rates, it is estimated to be Pleistocene. The formation is restricted in its distribution to the northern and central areas of the Basin and the depositing streams flowed from north and northeast to the west. The morphological character of the depositing streams is unknown, although they were substantially different from the present Darling (Riley & Taylor 1978). The Warrena Formation is a fluvial sheet sand similar in many respects to those discussed by Veevers and Rundle (1976).

The Walgett Formation averages 10 m thickness. It is a muddy unit composed dominantly of pedogenised montmorillonitic clays with minor amounts of sand (*c.* 95% quartz and 5% feldspar). This unit represents the 'flood basin' deposits of the present rivers in the central regions of the Basin. It is cut through by palaeochannels which have associated with them a sandy phase and a later muddy phase. These two phases are separated out as the Vauxhall and Barokaville Formations respectively. The Walgett Formation is overlain around the Basin margins by coarser grained units deposited by the modern streams (Riley & Taylor 1978).

DISCUSSION

It is possible that a warm, humid climate was required for the formation of the deep weathering profile on the Rolling Downs Group and a warm, humid but seasonal climate for the production of silcretes (Goudie 1973). Kemp (1978) shows that there were major changes in the Cainozoic climates in southeastern Australia, partly as a result of changes in ocean temperature and partly from the northerly drift of Australia from Antarctica. Ocean temperatures were warm from the Palaeocene to early Oligocene (Shackleton & Kennett 1975) and resulted in warm, humid continental climates reported by Kemp (1978) from examination of the floral assemblages from that period. The floral evidence suggests widespread areas of rainforest during the Palaeocene, Eocene and early Oligocene with rainforest giving way to more open forest in the late Oligocene. After the early Oligocene ocean surface temperatures decreased irregularly throughout the remainder of the Tertiary with two brief reversions of about 3° in the early Miocene. By the late Miocene the polar ice cap expanded and sea temperatures reached a low of about 4°. This resulted in a relatively arid phase on the continent and the change from forests to open grasslands.

The climatic and floral history is generally consistent with the known stratigraphy of the Upper Darling Basin. The deep weathering and lack of thick sediment bodies in the early Cainozoic could indicate warm humid climates and a landscape dominated by rainforest and/or forest vegetation. Several authors (Ruxton 1967, Wilson 1969, Fouriner 1949) have shown that there is significant sediment production in tropical rainforests. Langbein and Schumm (1958) have shown that while sediment is produced it is about one third that produced in more temperate climates. The majority of the material in the deeply weathered profiles preserved in both the eastern highlands and the Basin is dominated by clay sized components. This being so the size of the available material would allow it to be flushed through the system leaving only the coarser detritus in the Basin or catchment areas. It is however difficult to imagine the development of the Cumborah Gravel under warm-humid climates with forest vegetation. If the Mt. Charlotte Silcrete correlates with the second, late Oligocene, weathering phase (Canaway Profile of Idnurm & Senior 1978) this means the Cumborah Gravel was formed in a forested basin. This style of deposit is more in keeping with deposition under less densely vegetated arid to semi-arid conditions. Such conditions first occurred during the late Miocene.

There was a brief but distinct warming and associated increase in humidity during the early Pliocene, accompanied by the return of rainforest. It is during this phase, the present author suggests, that the Mt. Charlotte Silcrete developed in the Cumborah Gravel. This early Pliocene warming and rainforest resurgence is also reflected by the lack of any early Pliocene sediments.

If the equivalent of the late Oligocene Canaway Profile occurs in the Upper Darling Basin it has not been recognised or is inseparable from the early Eocene profile.

In the late Pliocene two significant events occurred in the Basin. The eastern source areas were uplifted and the climate changed from warm and humid to cooler, drier, less stable climates with alternately arid and more humid phases. As a result of these changes production of sediment from the eastern highlands increased and deposition of the three thick fluvial sequences in the Basin began. The detailed relation between the climatic events of the late Tertiary to Recent and the changes in style of fluvial deposition are unknown although some comments on the most recent changes are made by Riley and Taylor (1978).

The systematic change in clay mineralogy through the fluvial sequence reflects the change in the nature of the detritus formed in the provenance. The lower part of the sequence, rich in kaolinite was presumably derived from the thick early Tertiary weathering profiles of which relics are still preserved under Oligocene to Miocene basalt flows in places (Crook 1961), and from the late Tertiary weathering profiles of the basalts.

Once these kaolinitic profiles were stripped the eroded material became increasingly rich in montmorillonite as a result of weathering under climatic conditions more arid or similar to the present (Craig & Loughnan 1964).

CORRELATIONS

Table 1 is a correlation chart for some of the major Cainozoic Basins in eastern Australia, from the Karumba Basin to the Murray Basin. The correlations attained are relatively good and demonstrate the widespread nature of Cainozoic events in eastern Australia. Some of the major features include:

1. The widespread Cretaceous to early Eocene weathering and associated duricrusts throughout northern and central areas of eastern Australia.
2. The general absence of any depositional activity over wide areas of continental eastern Australia from the Eocene to Miocene, with the exception of deposition in marginal marine and internal drainage areas.
3. The extensive deposition of relatively thin sheet conglomerates and sands during the Miocene or late Miocene.
4. The widespread early to mid-Pliocene weathering event.
5. The very widespread development of continental fluvial sedimentation during the mid-Pliocene to Recent.

The synchroneity of these events over such a wide area of eastern Australia is remarkable and suggests extensive uniformity of climate and/or tectonism during the Cainozoic in eastern Australia. There is reasonable evidence (Wellman 1971) for widespread synchroneity of tectonic events throughout the Cainozoic in southeastern Australia. Independent evidence from northeastern Australia is more localised but supports the evidence of Wellman. The Cainozoic climatic history for southeastern Australia is relatively well known but the northeastern Australian climates for the same period are only poorly known. The correlations discussed here however suggest that the gross climatic variations were similar throughout eastern Australia during the Cainozoic.

ACKNOWLEDGMENTS

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TABLE 1

VICTORIAN MURRAY BASIN (2) Lawrence 1976 Gill 1973	MURRAY BASIN, EAST (2) Woolley & Williams 1977 and Woolley 1978	LACHLAN VALLEY (3) Williamson 1969	AGE	UPPER DARLING BASIN (4) Taylor 1976	EROMANGA BASIN (5) Senior (in Doutch 1976) Idnurm & Senior (in press)	KARUMBA BASIN (6) (Platform Segment only) Doutch 1976
Coonambidgal Fm. *fluvial*	Shepparton Fm. *fluvial*	Cowra Fm. *fluvial*	HOLOCENE	Barokaville Fm. Vauxhall Fm. Walgett Fm.	*younger river deposits*	*younger fluvial and fan deposits*
WIDGELLI PEDODERM						HOLROYD SURFACE *aeolian deposits*
Shepparton Fm. *fluvial*; KAROONDA SURFACE XX		Lachlan Fm. *fluvial*	PLEISTOCENE	Warrena Fm. *fluvial*; Come-By-Chance Fm. *fluvial*	*older river deposits*	*older Clara, Gilbert & Mitchell fan deposits*
Parilla Sand *marginal marine*; Bookpurnong Beds *marine*	Calivil Fm. *fluvial*		PLIOCENE Late, Early	MT CHARLOTTE XX SILCRETE XX		
Calivil Fm. *fluvial*; Torrumbarry clay; MURRAY GP. *marine carbonate deposition*		Glenlogan Gravel *fluvial*	MIOCENE Late, Mid, Early	Cumborah Gravel *fluvial*	Glendower Fm. *fluvial*; Etadunna Fm. *fluvial*	Wyabba Beds *continental & marine*
Olney Fm. *deltaic tidal & lagoonal*	Olney Fm. *fluvial & ? marginal marine*		OLIGOCENE Late, Early	*fluvial deposition in east*	XX CANAWAY PROFILE; ++ CURALIE SILCRETE; Eyre Fm. *fluvial*	
Warina Sand *fluvial*	Warina Sand *fluvial*		EOCENE Late, Early			
			PALAEOCENE Late, Early	XX LLANILLO SILCRETE	+ MORNEY PROFILE +	
			CRETACEOUS Late, Early	ROLLING DOWNS GROUP	ROLLING DOWNS GROUP	Bulimba Fm.

X Silcrete
\+ Ironstone